# HRP Job Aid

## Magnets, Magnetic Metals, and Magnetic Components and Systems

| Magnetic Metals | ECCN |
|---|---|
| Magnetic metals | 1C003 |
| Amorphous alloy strips | 1C003 |
| Metals with high initial relative (magnetic) permeability | 1C003.a |
| Magnetostrictive alloys | 1C003.b |
| Nanocrystalline alloy strips | 1C003.c |
| Alloy strips, magnetic | 1C003.c |
| Magnetic alloy strips | 1C003.c |

### Key Points

- Technical interpretation by a subject matter expert of the rather complex magnetic properties under ECCN 1C003 is encouraged on a case-by-case basis
- Be aware of the following indicators for possible export-controlled magnetic metals:
  - Very thin metal strips or metal ribbon (thickness of ≤0.05 mm)
  - Any reference to *magnetostriction*
  - Any reference to *amorphous alloy* or *nanocrystalline* alloy
  - Terfenol-D
  - Galfenol
  - Metglas®
  - Finemet®
  - Metal products from Hitachi Metals, Honeywell, and Allied Signal
  - Materials and engineering science research and development laboratories (e.g., Ames Laboratory)

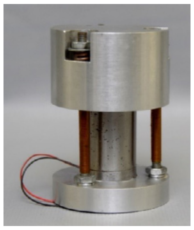
***Note:*** *A standard piece of paper is about 0.05 mm thick.*

### Key Terms

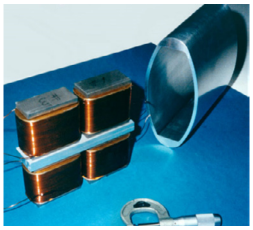
***Permeability*** is the measure of magnetization that a material obtains in response to an applied magnetic field. Controlled magnetic metals have a high relative permeability (≥120,000).

***Magnetostriction*** is a property of magnetic materials that causes them to change their shape or dimensions (e.g., expand or contract) during the process of magnetization. Magnetostrictive materials can convert magnetic energy into kinetic energy (e.g., motion), or the reverse, and are used in actuators, transducers, and sensors.

## Key Materials



Terfenol-D actuator



Terfenol-D driver assembly for underwater acoustic transducer

### *Terfenol-D*

- Among alloys, Terfenol-D exhibits the highest known magnetostriction. It is shiny grey in appearance
- Terfenol-D is named after the three different metals it is composed of—terbium (Tb), iron (Fe), dysprosium (Dy)—and the laboratory where it was first developed—the Naval Ordnance Laboratory (NOL)
- Terfenol-D is excellent for manufacturing low-frequency, high-powered underwater acoustics (e.g., sonar systems)
- Recent applications include use in fuel injectors in diesel engines

Amorphous alloy strips (ribbon)

### *Metglas*

- A common magnetostrictive material is an amorphous alloy with the trade name Metglas
- Metglas is manufactured by a subsidiary of Hitachi Metals America Ltd. in Conway, South Carolina, that is a world-leading producer of amorphous metal ribbon (strip)
- Amorphous metals lack a crystalline structure like other magnetic materials, which results in a much higher resistivity, higher permeability, and lower loss at higher frequencies than other magnetic materials
- These unique magnetic properties are well suited for wide range of applications from distribution transformers, magnetic antitheft tags, motors, high-frequency inductors, and magnetic micro-electro-mechanical systems

### *Finemet*

- An alloy ribbon developed by Hitachi Metals
- First nanocrystalline, soft magnetic material in the world (extremely small grain size on the order of billionths [nano] of a meter)
- Uses advances in material technology and improved magnetic characteristics for products and applications in electromagnetic noise suppression devices, common mode chokes, current sensors, magnetic sensors, magnetic amplifiers, high-voltage pulse transformers, and high-frequency power transformers

Galfenol wire (FeGa alloy; size 0.8 mm; magnetostrictive material)

### *Galfenol*

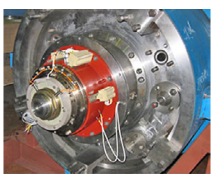
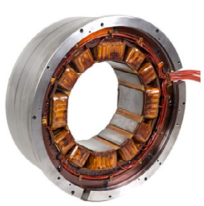
- A magnetostrictive alloy of iron and gallium
- Named by U.S. Navy researchers in 1998 when they discovered that adding gallium to iron could amplify iron's magnetostrictive effect up to tenfold
- Similar properties to Terfenol-D but not as brittle; can be machined and welded
- Produced in sheet and wire form
- Applications include sonar detectors, actuators for precision machine tools, active antivibration systems, and anticlogging devices for sifting screens and spray nozzles

## ECCN 2A001 Magnetic Bearings

Active magnetic bearing systems ..................................... 2A001.c
Bearings, magnetic (active) ................................................ 2A001.c

### Key Points

- Active magnetic bearings use electromagnets that require continuous power input and an active control system to keep the load stable (i.e., look for associated/nearby advanced electronic control system)
- Major manufacturers:
  - o Waukesha Magnetic Bearings
  - o Dresser-Rand (Synchrony® trade name)
- Export-controlled active magnetic bearings and bearing systems are based on material properties (flux densities and yield strengths of the magnetic materials) or design features (homopolar design for actuators to provide a constant bias flux; the use of high-temperature position sensors)

Radial magnetic bearing for positioning a rotor using four electromagnets

### Background

- **Magnetic bearings** support a load using magnetic levitation and support moving parts without physical contact (e.g., levitate a rotating shaft and permit relative motion with very low friction and no mechanical wear)
- **Active magnetic bearings** are a type of magnetic bearing in which non-contact support of a shaft is achieved by using magnetic forces produced by actively controlled electromagnets
- Typical applications include blowers, compressors, gas and steam turbines, generators, motors, pumps, and turbogenerators

## ECCN 3A001, 3A201 Superconductive Electromagnets

Electromagnets, superconductive ..................................... 3A001.e.3
Electromagnets, superconductive ..................................... 3A201.b

### Physical Features

- Large straight welded metal cylindrical shape (horizontal or vertical) with an opening in the center that passes electricity through a cryogenically cooled coil with multiple loops to generate a magnetic field
- Piping for liquid helium flow cooling embedded into the magnet structure
- Electrical connections to and from the magnet

## Key Points

- Other required components typically located in the immediate vicinity: Dewars for storage of cryogenic supplies, such as liquid helium and nitrogen; vacuum pumps; liquid nitrogen and liquid helium controllers and monitors; vacuum gauges; temperature sensors; cryothermometers; and cryogenic tubing
- Export-controlled superconductive electromagnets are based on attributes of the magnetic field (intensity measured in Teslas; uniformity over the central inner volume) and design features (length to inner diameter [ID]; ID of windings; time to fully charge or discharge)
  - o Large (>30 cm or 12 in.) ID and length at least 2× diameter warrant special concern
- 3A001.e.3 does not control superconductive electromagnets or solenoids especially designed for magnetic resonance imaging (MRI) medical equipment
- 3A201.b does not control magnets especially designed for and exported as parts of medical nuclear magnetic resonance imaging systems

## Applications

- Plasma separation process for uranium enrichment
- Nuclear magnetic resonance or magnetic resonance imaging systems
- High-energy particle accelerators and certain types of magnetic confinement thermonuclear fusion reactors
- Ion cyclotron resonance measurements
- Production of integrated circuits and optical coatings
- Magnetic separation and levitation


Superconductive electromagnetic with off-center hollow channel


4.7 Tesla, 31 cm bore system for nuclear magnetic resonance

Example of a Dewar for storing liquefied gases required for superconducting electromagnet operation


Superconductive electromagnet packed inside a shipping crate with typical markings and labels

# ECCN 0A999 Ring Magnets

Ring magnets .............................................................. 0A999.a

## Key Points

- A ring magnet is a thin flat circular magnet with a thickness that does not exceed the diameter, and there is a hole through the center
- Ring magnets (all types without the need to meet any specific technical parameters) are export controlled to North Korea for antiterrorism reasons under ECCN 0A999.a
- Ring magnets especially designed or prepared as part of the upper suspension bearing of a gas centrifuge for the separation of uranium isotopes are subject to the export licensing authority of the U.S. Nuclear Regulatory Commission (see 10 CFR Part 110)

Example of a ring magnet

  - Ring magnets used for uranium enrichment must meet stringent requirements, such as specific inner/outer diameter ratios; sufficient magnetic strength; or homogeneity (uniform composition).
  - Ring magnets used for uranium enrichment are most likely made of Al–Ni–Co (Alnico); samarium–cobalt alloys; or other materials, such as Nd–Fe–B or ceramic (ferrite).

## Background

- Ring magnets are commonly used when a mechanical attachment method is needed to secure the magnet.
- Ring magnets are widely used in such applications as holding, motors, consumer electronics, medical, sensors and loudspeakers.
- There are four categories of permanent magnets: NdFeB, SmCo, Alnico, and ceramic (ferrite)

### *Alnico Ring Magnets*

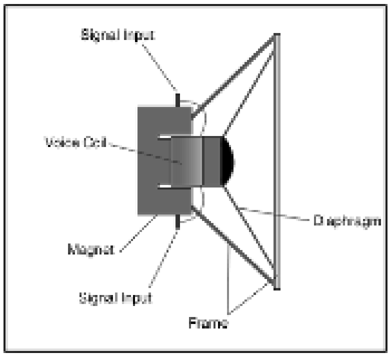
- Primarily made up of a combination of Al, Ni, and Co, but they can also include Cu, Fe, and Ti.
- Commonly used for industrial applications such as rotating machinery, meters, instruments, sensing devices, holding applications and more.

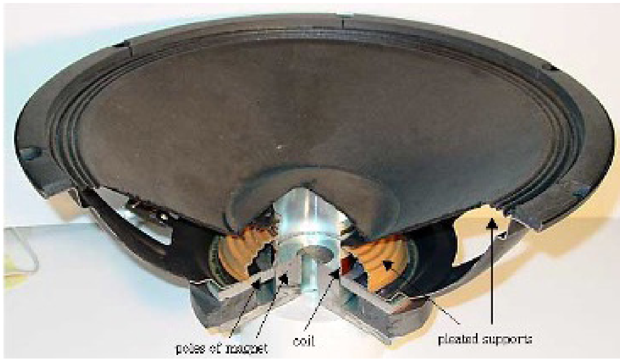
### *Rare-Earth Ring Magnets*

- Two types of rare earth magnets are available: NdFeB and SmCo.
- Rare earth magnets are the strongest type of permanent magnets made.
- Neodymium magnets are the strongest rare earth magnets and the strongest magnets in the world.
- Rare earth magnets have replaced other magnetic materials to make a design smaller but achieve the same result.
- Neodymium ring magnets are used extensively in applications in the jewelry, medicine, automotive, aerospace, and power-generation industries.

### *Ceramic Ring Magnets*

- Ceramic magnets (also known as *ferrite* magnets) are part of the permanent magnet family, and they are the lowest priced ring magnets.
- These magnets are commonly used in loudspeakers, for holding applications, door closures, light fixtures, and torque drives.



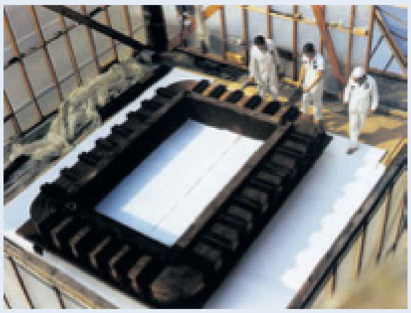

Schematic and photograph of a loudspeaker, identifying pertinent parts, including a ceramic ring magnet

## ECCN 1B226 Electromagnetic Isotope Separators (EMIS)



### Key Points

- EMIS devices are used to enrich uranium for use in nuclear explosive devices and to prepare other high-purity elements for nuclear research purposes.
- EMIS devices are also used to separate a wide variety of isotopes (virtually all chemical elements) for medical and research purposes.
- Export-controlled EMIS devices are based on a single design feature: Designed for, or equipped with, single or multiple ion sources capable of providing a total ion beam current of 50 mA (milliamps) or greater.
- Electromagnetic isotope separators that are especially designed or prepared for use in separating uranium isotopes are subject to the export licensing authority of the U.S. Nuclear Regulatory Commission (see 10 CFR Part 110).



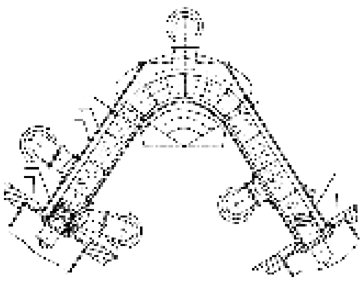
EMIS magnet coils especially designed or prepared for an alpha calutron for uranium enrichment

EMIS collector consisting of graphite receivers designed and spaced to collect the 10 stable isotopes of tin

### Sector-Type EMIS Devices

- Generally used in a laboratory
- Resemble laboratory mass spectrometers
- Typically have beam currents of ≤10 mA and a single source
- May be physically massive and consume large amounts of electric power (30–70 kW), but rarely capable of providing an ion beam current of ≥ 50 mA

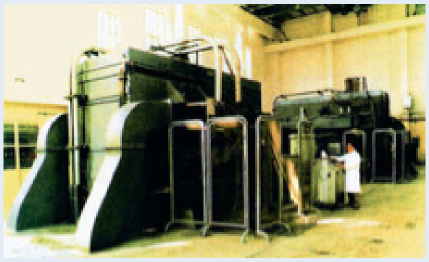
**Note:** *The maximum current of an ion source can be estimated by the current of the high-voltage power supply. A 50 mA ion source will require approximately a 100 mA power supply at 30–60 kV.*



Schematic of a Russian sector-type EMIS device

### Tank-Type EMIS Devices

- Large units used for producing gram to kilogram quantities of separated isotopes
- May have one to four or more ion sources, each having a beam current in excess of 100 mA



Tank-type EMIS device of Russian design

## DOE/NNSA High Risk Property

[https://hrp.doe.gov](https://hrp.doe.gov)

[https://ecap.doe.gov](https://ecap.doe.gov)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